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Biological Effects of Radiations

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Abstract—Every time we come across with many forms of radiations. Exposure to radiations can be harmful or beneficial. One of the most prominent effects of radiation is heating effect. In this work a mathematical model of thermal effect of radiation is proposed. This model can be used to calculate the change in temperature of material due to radiation exposure.
Keywords— Radiations, Specific absorption rate.

INTRODUCTION

Radiation is basically energy on move. Radiations can originate from natural sources or from artificial source. Natural sources of radiations include Earth, living organism, plants, Sun, Stars and other terrestrial bodies. Earth itself produces radiations due to presence of radioactive materials. Due to presence of radioactive materials in soil, water, and air they are inhaled by living organism and plants in turn these living organism and plants also becomes source of radiations. Sun is the major source of radiations which emits Ultraviolet, infrared radiations along with visible light. Radiations in microwave frequency band enter the atmosphere of earth from outside the solar system. Strength of radiations from sun or from stars various in different parts of geographical area. Fig 1 represents the sources of natural radiations.

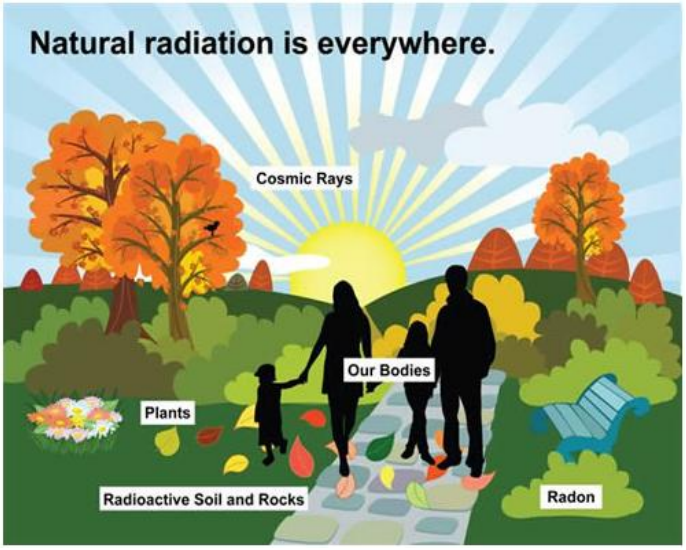

Fig. 1 (Natural Sources of radiations) [1]

Artificial sources of radiations include radiations from cellular towers, from medical diagnosis and treatment like X rays, MRI, CT Scan and from the nuclear waste in nuclear power generation.Sources of artificial radiation are shown in Fig(2).

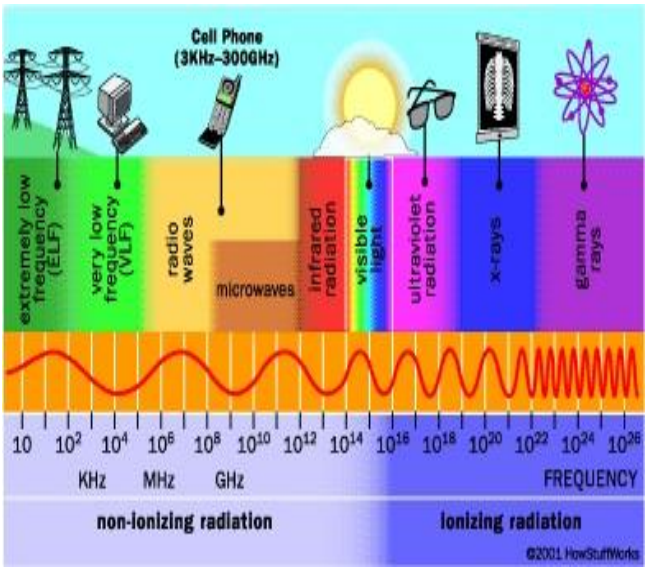

Fig. 2 (Artificial Sources of radiations) [2]

One of the common properties of all types of radiation is that they are all electromagnetic waves. Electromagnetic wave consists of electric field and magnetic field. The direction of electric field, magnetic field and direction of propagation of electromagnetic waves are perpendicular to each other. Electromagnetic waves contain energy which is proportional to electric field and magnetic field constituting the wave. If the strength of electric field in wave is E and strength of magnetic field in wave is H then power density in wave i.e. power per unit area (P) is given by the cross product of electric field and magnetic field.

$$P = E \quad \text{----------1}$$

The total power contained in electromagnetic signal is evaluated by integrating the power density over area A. If

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spherical coordinates are used then expression of total power linked with the wave is given by equation 2.

$$E = \int_{\theta_1}^{\theta_2} \int_{\emptyset_1}^{\emptyset_2} P\, r^2 \sin\theta \; d\theta \qquad \text{_____2}$$

As all waves contain some energy so they have the capability to imitate some physical changes or chemical changes when they strike the material. Level of change depends upon the energy contained in the wave. Physical change is concerned with thermal effects of material and chemical changes are concerned with ionization of the material. All types of radiations produce thermal effects when they strike the material. When electromagnetic wave strike the material due to transfer of energy they produce heating effects in the material. The heating effect depends on the energy contained in the wave. Depending upon the energy contained in electromagnetic waves radiations are further classified as ionizing radiations and non-ionization radiations. Ionization is a process in which in which electrons are detached from the atoms thus creating positive and negative charges. Radiations which have the capability of ionization may damage human tissues and can cause serious health problems. Fig 3 presents spectrum indication some ionized and non-ionized radiations along with the sources producing these radiations.

Fig. 3 (Frequency range capable of ionization and non-ionization.) [3]

Another important property of radiations is the penetrating capability. The penetrating capability of radiations depends on its frequency, conductivity and permeability of the material in which wave is penetrating. Depth of penetration signifies under these conditions. This is the distance at which wave is attenuated by a factor of 1/*e* of its initial value. Information about penetration depth of electromagnetic waves is provided in Fig. 4

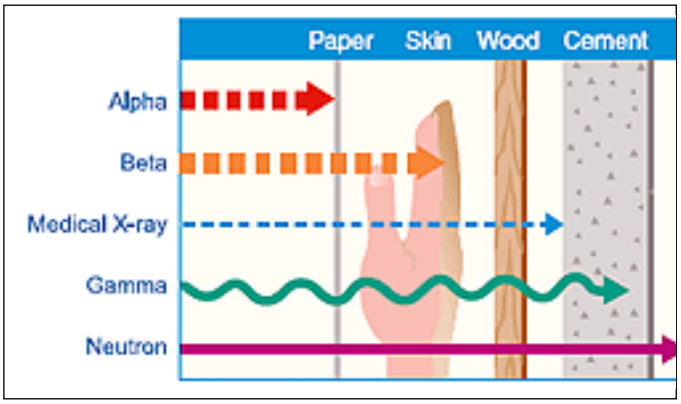

Fig. 4 (Frequency range capable of ionization and non-ionization.) [4]

LIVING CELL STRUCTURE

Every living cell is composed of million or trillions of cells. Cells replicate themselves for, the growth of living organism, for maintenance and repair, and for the purpose of reproduction. Outermost part of cell is cell membrane which allows only selective material to go inside and come outside the cell. Inside of cell is known as Protoplasm which consists of a fluid like material called cytoplasm and a nucleus. The structure of a cell with its description is shown in Fig 5.

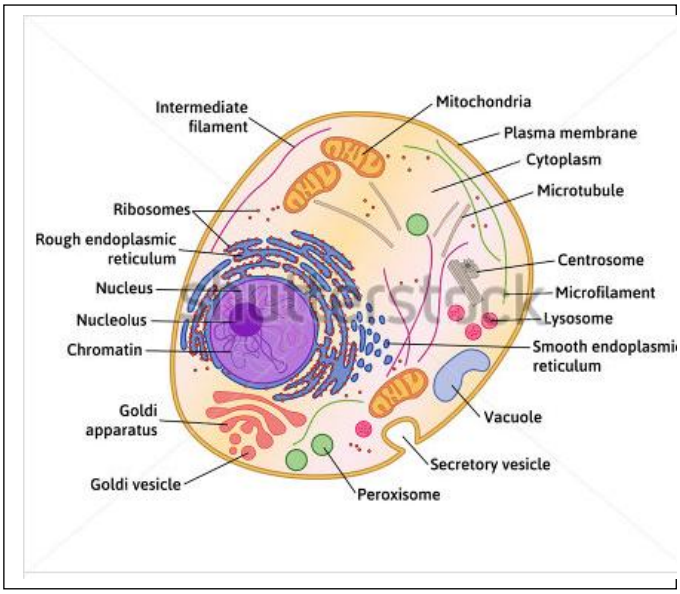

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Fig. 5 (Cell structure)[5]

Functions of cell are controlled and managed by its nucleus. Structure of nucleus is as shown in Fig 6.

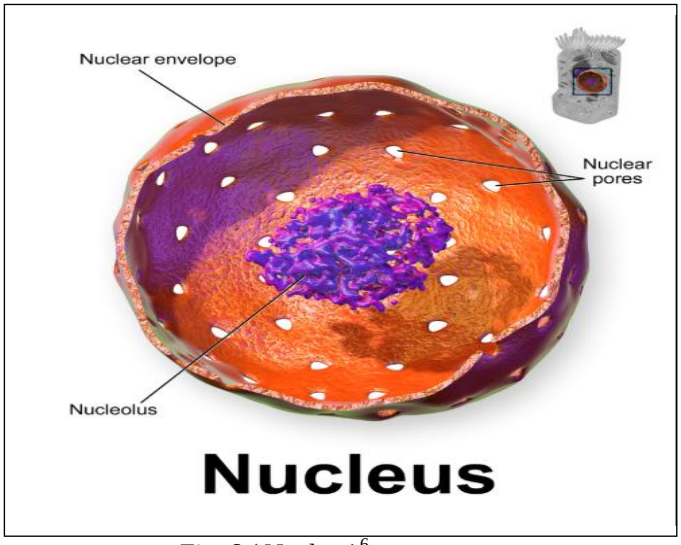

Fig. 6 (Nucleus)[6]

Nucleus contains nucleoplasm in which nucleotides, enzymes and other molecules are dissolved. The basic element which is concerned with reproduction and repair of cell is Deoxyribonucleic acid (DNA) which is present in nucleus. Structure of DNA is as shown in Fig 7.

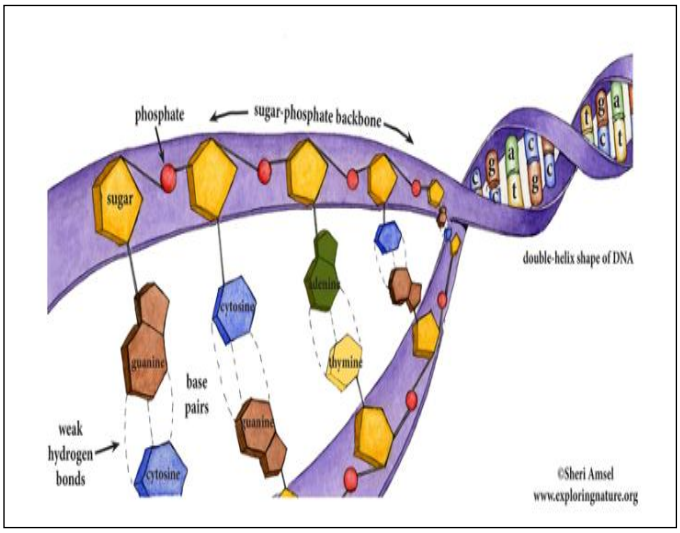

Fig. 7 (Nucleus)[7]

DNA is made of double helix structure. Each strip of helix is made of sugar, phosphate and nitrogenous base. Base is made of Adenine(A), Guanine(G), Cytosine(C), Thymine(T). Here A is always bounded with T and G is always bounded with C between two strands of DNA. Cell replication is possible due to self-replicable property of DNA. DNA has the property to unzip itself as shown in Fig 8. Due to presence of free nucleotides in the nucleus bases are reconnected to unzipped strands to form two pairs of twisted strands.

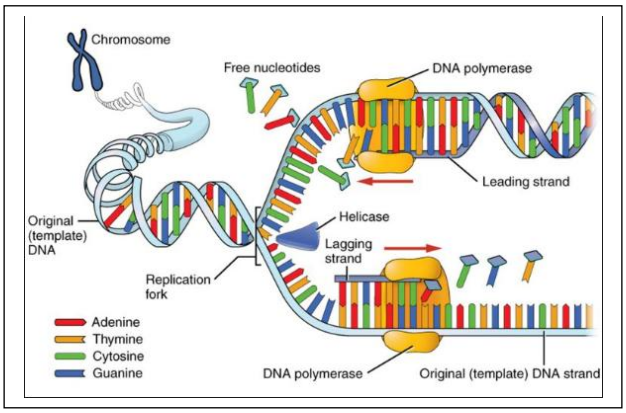

Fig. 8(Reproduction of DNA)[8]

EFFECTS OF RADIATIONS

Exposure to potentially high radiations can cause serious health effects to living cells. When high energy radiations encounter the living cellsthey may break the bonds between phosphates, sugar and between two bases as shown in Fig 9.

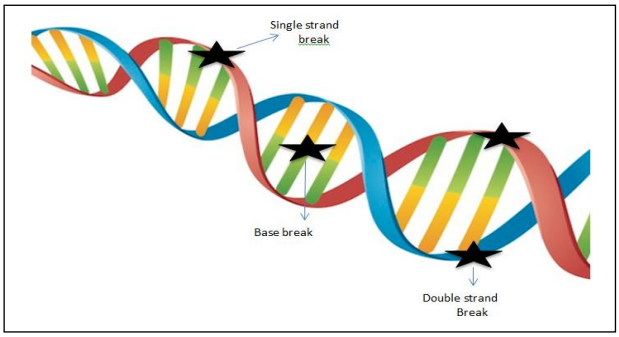

Fig. 9(DamagedDNA due to radiations)

Living tissues can cure this damage by using natural metabolism process if duration of exposure of radiations is small. However if duration and intensity of radiations is high unnatural breakage of strands of DNA can produce more number of DNA strands by process of replication. Each

damaged strip can produce two more DNA strands as shown in Fig 10.

Fig. 10 (Reproduction due to damaged DNA strip)

Due to continues exposure by radiations multiple copies of DNA are produced which in turn produce multiple copies of cells. Production of multiple copies of cells under uncontrolled manner leads to cancer.

Conclusion

It can be concluded that uncontrolled growth of cells due to uncontrolled growth of DNA strands leads to cancer disease. Persistence exposure of radiations having energy more than required to break bonds between phosphates, sugar and bases can be one cause of cancer.

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